Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati

(Autonomous)

Department of Mathematics

2019 Pattern

T. Y. B. Sc. (Mathematics)

Semester	Course Code	Title of Course	No. of Credits	No. of Lectures
V	MAT 3501	Metric Spaces	3	48
	MAT 3502	Real Analysis I	3	48
	MAT 3503	Group Theory	3	48
	MAT 3504	Ordinary Differential Equation	3	48
	MAT 3505	Operation Research	3	48
	MAT 3506	Number Theory	3	48
	MAT 3507	Practical based on MAT 3501 and MAT 3502	2	48
	MAT 3508	Practical based on MAT 3503 and MAT 3504	2	48
	MAT 3509	Practical based on MAT 3505 and MAT 3506	2	48
VI	MAT 3601	Complex Analysis	3	48
	MAT 3602	Real Analysis II	3	48
	MAT 3603	Ring Theory	3	48
	MAT 3604	Partial Differential Equation	3	48
	MAT 3605	Optimization Techniques	3	48
	MAT 3606	Lebesgue Integration	3	48
	MAT 3607	Practical based on MAT 3601, MAT 3602, and MAT 3603	2	48
	MAT 3608	Practical based on MAT 3604, MAT 3605, and MAT 3606	2	48
	MAT 3609	Mathematics Project	2	48

Choice Based Credit System Syllabus (2019 Pattern)

Class: T.Y.B.Sc. (Semester – V)
Course Code: MAT 3501
Course: 1 **Title of the Course:** Metric Spaces
Credit: 3 **No. of Lectures:** 48

A) Course Objectives:

1. Develop a rigorous understanding of metric spaces as a foundation for advanced analysis.
2. Learn to define and manipulate distances in metric spaces.
3. Grasp the concepts of convergence and completeness in metric spaces.
4. Explore the topological properties of metric spaces, including open and closed sets, subspaces, and separation axioms.
5. Analyze continuity and its variations (uniform continuity, homeomorphism) in the context of metric spaces.
6. Investigate connectedness and its different forms (connected, locally connected, arcwise connected) in metric spaces.
7. Introduce the concept of compactness in metric spaces and its applications.

B) Course Outcomes:

1. Students will be able to define a metric space and provide examples of common metric spaces.
2. Students will be able to prove statements about distances in metric spaces and use them to solve problems.
3. Students will be able to determine the convergence of sequences in a metric space and identify Cauchy sequences.
4. Students will be able to explain the concept of completeness and demonstrate its importance in metric spaces.
5. Students will be able to define open and closed sets in a metric space and prove basic theorems related to them.
6. Students will be able to analyze the continuity of functions between metric spaces and apply extension theorems.
7. Students will be able to identify connected and compact sets in metric spaces and prove their key properties.

TOPICS/CONTENTS:

Unit 01: Basic Concepts [*8 Lectures*]

- Inequalities
- Metric Spaces
- Sequences in Metric Spaces
- Cauchy Sequences
- Completion of a Metric Space

Unit 02: Topology of a Metric Space [*8Lectures*]

- Open and Closed Sets
- Relativisation and Subspaces

- Countability Axioms and Separability
- Baire's Category Theorem

Unit 03: Continuity [*10 Lectures*]

- Continuous Mappings
- Extension Theorems
- Real and Complex-valued Continuous Functions
- Uniform Continuity
- Homeomorphism, Equivalent Metrics and Isometry

Unit 04: Connected Spaces [*8 Lectures*]

- Connectedness
- Local Connectedness
- Arcwise Connectedness

Unit 05: Compact Spaces [*10 Lectures*]

- Bounded sets and Compactness
- Other Characterisations of Compactness
- Continuous Functions on Compact Spaces
- Locally Compact Spaces
- Compact Sets in Special Metric Spaces

Unit 05: Product Spaces [*4 Lectures*]

- Finite and Infinite Products of Sets
- Finite Metric Products
- Infinite Metric Products
- Cantor Set

Textbook:

Satish Shirali and Harkrishan L. Vasudeva, Metric Spaces, Springer

Reference Books:

1) O'Searcoid, Metric Spaces, Springer
2) James R. Munkres, Topology, Pearson
3) Richard R. Goldberg, Methods of Real Analysis, Oxford & IBH Publishing Co Pvt.Ltd

Mapping of Program Outcomes with Course Outcomes

Class: TYBSc (Sem V) **Subject:** Mathematics
Course: Metric Spaces **Course Code:** MAT 3501
Weightage: 1=weak or low relation, 2=moderate or partial relation, 3= strong or direct relation.

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	2				2			2
CO 2	3	3		1		2			3
CO 3	3	3		1		2			3
CO 4	3	3		1		2			3
CO 5	3	3		1	1	2			3
CO 6	3	3		1	1	2			3
CO 7	3	3		1	1	2			3

Justification for the mapping

PO 1: Disciplinary Knowledge:
Strong understanding of metric spaces forms a core component of advanced mathematics.
PO2: Critical Thinking and Problem Solving:
Solving problems and proving theorems in metric spaces enhances critical thinking.
PO4: Research-related skills and Scientific temper:
Metric space theory provides a basis for research in analysis but requires further development in advanced studies.
PO5: Trans-disciplinary Knowledge:
Applications of metric spaces can relate to other fields, especially in higher mathematical contexts.
PO6: Personal and professional competence:
Competence in the subject improves analytical thinking and professionalism.
PO9: Self-directed and Life-long learning:
The rigorous nature of metric spaces encourages independent learning and continued study in mathematics.

Choice Based Credit System Syllabus (2019 Pattern)

Class: T.Y.B.Sc. (Semester – V)
Course Code: MAT 3502
Course: 2 **Title of the Course:** Real Analysis I
Credit: 3 **No. of Lectures:** 48

A) Course Objectives:

1. Define sets and comprehend foundational concepts such as subsets, intersections, unions, complements, and power sets.
2. Analyze and manipulate functions, including composition, inverses, domains, ranges, and graphing techniques for real-valued functions.
3. Investigate advanced concepts like equivalence relations, countability, and the Cantor set.
4. Describe and comprehend the fundamental properties of sequences of real numbers, including terms such as boundedness, monotonicity, and convergence criteria.
5. Analyze and differentiate between convergent and divergent sequences, employing various convergence tests and techniques such as limit definitions, Cauchy sequences, and the comparison test.
6. Apply the knowledge of convergence and divergence of sequences to solve real-world problems in different fields such as calculus, mathematical analysis, and engineering.
7. To enable students to comprehend the concepts of convergence and divergence in series of real numbers.
8. To familiarize students with fundamental convergence tests such as the Comparison Test, Ratio Test, and Root Test.

B) Course Outcomes:

1. Students will be able to demonstrate proficiency in performing set operations, including unions, intersections, and complements, and apply these operations to solve problems in various contexts.
2. Students will be able to apply the concepts of equivalence relations, countability, and the Cantor set to solve complex problems in diverse areas, showcasing an understanding of their practical applications.
3. Students will be able to identify convergence or divergence in a given sequence of real numbers, analyze the behavior of sequences toward specific limits or infinity, and apply relevant tests to determine convergence or divergence.
4. Students will be proficient in using the Cauchy criteria to establish convergence, demonstrate the properties of Cauchy sequences, and apply related theorems to analyze and solve problems involving real sequences.
5. Students will be able to apply their knowledge of convergence, divergence, and Cauchy sequences to model and analyze real-world scenarios, interpret their mathematical significance, and communicate findings effectively using mathematical reasoning.
6. Students will be able to distinguish between convergent and divergent series within the context of real numbers.
7. Students will apply convergence tests rigorously to ascertain convergence or divergence of different series encountered in real-world applications.

TOPICS/CONTENTS:

Unit 01: Sets and functions [*12 Lectures*]

- Sets and elements
- Operations on sets
- Functions
- Real-valued functions
- Equivalence. Countability
- Real numbers
- Least upper bounds

Unit 02: Sequences of Real Numbers [*18 Lectures*]

- Definition of sequence and subsequence
- Limit of a sequence
- Convergent sequences
- Divergent sequences
- Bounded sequences
- Monotone sequences
- Operations on convergent sequences
- Operations on divergent sequences
- Limit superior and limit inferior
- Cauchy sequences

Unit 03: Series of Real Numbers [*18 Lectures*]

- Convergence and divergence
- Series with nonnegative terms
- Alternating series
- Conditional convergence and absolute convergence
- Tests for absolute convergence
- Series whose terms form a nonincreasing sequence
- The class l^2

Text book:

R. R. Goldberg, *Methods of Real Analysis*, Oxford & I. B. H. Publications, 1970.

Ch. 1, Art 1.1 to 1.7; Ch. 2, Art 2.1 to 2.10; Ch. 3, Art 3.1 to3.7 and 3.10.

Reference Books:

1. Ajit Kumar and S.Kumaresan, *A Basic Course in Real Analysis*, CRC Press, Second Indian Reprint 2015.
2. D. Somasundaram and B. Choudhary, *A first course in Mathematical Analysis*, Narosa Publishing House, 1997.
3. Robert, G. Bartle, Donald Sherbert, *Introduction to Real Analysis*, Third edition, John Wiley and Sons.
4. Shantinarayan and Mittal, *A course of Mathematical Analysis*, Revised edition, S. Chand and Co. (2002).
5. S.C. Malik and Savita Arora, *Mathematical Analysis*, New Age International Publications, third Edition, (2008).

Mapping of Program Outcomes with Course Outcomes

Class: TYBSc (Sem V) **Subject:** Mathematics
Course: Real Analysis I **Course Code:** MAT 3502
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	2	2							
CO 2	3	2			1				1
CO 3	3	3			1				
CO 4	2	3		1	1				
CO 5	2	2							
CO 6	2	2							
CO 7	3	3						1	1

Justification for the mapping

PO1: Disciplinary Knowledge
CO1: Mastering set operations enables students to solve diverse problems across disciplines by efficiently manipulating relationships between sets through unions, intersections, and complements.
CO2: Understanding equivalence relations, countability, and the Cantor set enables students to discern patterns, classify diverse data, and model complex systems across disciplines, fostering problem-solving prowess through practical application.
CO3: Understanding convergence and divergence in sequences of real numbers is foundational in various disciplines, enabling precise analysis of limits and applications of convergence tests for robust mathematical problem-solving.
CO4: Mastering the Cauchy criteria empowers students to rigorously assess convergence, unveil properties of sequences, and effectively employ theorems to tackle real-world problems in sequence analysis.

CO5: Understanding convergence, divergence, and Cauchy sequences equips students with the tools to mathematically model real-world phenomena, interpret their implications, and communicate findings coherently, enhancing their disciplinary knowledge and analytical abilities.
CO6: Understanding the distinction between convergent and divergent series is crucial in real numbers to grasp the behavior and limits of mathematical sequences.
CO7: Students rigorously apply convergence tests to ensure accuracy when determining the convergence or divergence of series in real-world applications within Disciplinary Knowledge.

PO2: Critical Thinking and Problem Solving
CO1: Understanding set operations fosters logical thinking and problem-solving by enabling students to manipulate and combine elements, crucial for solving diverse real-world problems across various contexts.
CO2: Understanding equivalence relations, countability, and the Cantor set cultivates analytical skills essential for tackling multifaceted problems across disciplines, demonstrating the practicality of abstract mathematical concepts in fostering critical thinking and problem-solving prowess.
CO3: Understanding convergence or divergence in sequences of real numbers enhances critical thinking by sharpening analytical skills and applying test strategies to ascertain the behavior of sequences towards specific limits or infinity.
CO4: Students will enhance critical thinking by mastering the Cauchy criteria, empowering them to analyze convergence, properties, and problem-solving involving real sequences.
CO5: Understanding convergence, divergence, and Cauchy sequences equips students with the essential tools to analyze real-world scenarios through mathematical models, fostering effective communication and interpretation of findings to solve complex problems.
CO6: Understanding convergent and divergent series in the context of real numbers cultivates analytical thinking by discerning the limits and behaviors of mathematical sequences, fostering critical problem-solving skills.
CO7: Applying convergence tests rigorously ensures accurate determination of convergence or divergence, crucial for real-world applications' validity and reliability in Critical Thinking and Problem Solving.

PO4: Research-related skills and Scientific temper
CO3: Mastering Cauchy criteria empowers students to rigorously assess convergence, analyze sequence properties, and apply theorems effectively, fostering essential research skills and a scientific mindset for problem-solving in real sequences.

PO5: Trans-disciplinary Knowledge
CO2: Understanding equivalence relations, countability, and the Cantor set enables students to unravel intricate problems across disciplines, fostering a versatile problem-solving approach essential in trans-disciplinary fields.
CO3: Understanding convergence and divergence in sequences of real numbers is essential across various disciplines as it facilitates analysis of patterns, predictions of outcomes, and modeling behaviors in diverse systems.
CO4: Mastering the Cauchy criteria equips students to rigorously analyze convergence, explore the characteristics of Cauchy sequences, and effectively solve real-world problems across diverse fields reliant on sequences' properties.

PO8: Environment and Sustainability
CO7: Applying convergence tests rigorously ensures accurate determination of series convergence or divergence, critical in modeling and analyzing real-world environmental and sustainability phenomena.

PO9: Self-directed and Life-long Learning

CO2: Understanding equivalence relations, countability, and the Cantor set fosters problem-solving skills across diverse fields, facilitating self-directed learning by applying these concepts practically, thereby nurturing life-long learning capabilities.

CO7: Rigorous application of convergence tests ensures accurate determination of convergence or divergence in series, vital for real-world applications, fostering self-directed and lifelong learning in mathematical analysis.

Choice Based Credit System Syllabus (2019 Pattern)

Class: T.Y.B.Sc. (Semester – V)
Course Code: MAT 3503
Course: 3 **Title of the Course:** Group Theory
Credit: 3 **No. of Lectures:** 48

A) Course Objectives:

1. To recognize the mathematical objects called groups.
2. To link the fundamental concepts of groups and symmetries of geometrical objects.
3. To explain the significance of the notions of cosets, normal subgroups and factor groups.
4. To analyse consequences of Lagrange's theorem.
5. To describe about structure preserving maps between groups and their consequences.
6. To learn Automorphisms for constructing new groups from the given group.
7. To apply group theory to solve some special problems in elementary number theory like Fermat's Theorem, Wilson's Theorem etc.

B) Course Outcomes:

1. Students will able to recognize the mathematical objects called groups.
2. Students will able to link the fundamental concepts of groups and symmetries of geometrical objects.
3. Students will able to explain the significance of the notions of cosets, normal subgroups and factor groups.
4. Students will able to analyse consequences of Lagrange's theorem.
5. Students will able to describe about structure preserving maps between groups and their consequences.
6. Students will able to learn Automorphisms for constructing new groups from the given group.
7. Students can apply group theory to solve some special problems in elementary number theory like Fermat's Theorem, Wilson's Theorem etc.

TOPICS/CONTENTS:

Unit 01: Introduction to Groups [*8Lectures*]

- Symmetries of square
- The Dihedral groups
- Definition and examples of groups
- Elementary properties of groups

Unit 02: Finite Groups and Subgroups [*8Lectures*]

- Order of group, order of elements.
- Subgroup Tests and examples.
- Center of a group
- Centralizer of element.
- Cosets: definition and properties

- Lagrange's theorem and corollary

Unit 03: Cyclic Groups [*10Lectures*]

- Properties of cyclic groups and examples
- Order of finite cyclic groups
- Generators of finite cyclic groups
- Generators of Zn
- Fundamental theorem of Cyclic Groups

Unit 04: Permutation Groups [*8Lectures*]

- Definition and examples
- Permutation on $S_{n,}$ detail discussion of S_3
- Cycle notation
- Properties and theorems on permutation.
- Even odd permutation

Unit 05: Normal Subgroup [*4Lectures*]

- Definition
- If G is abelian then every subgroup of G is normal subgroup
- Theorems on Normal subgroup.

Unit 06: Homomorphism and Isomorphism's [*10Lectures*]

- Homomorphism and fundamental theorem of homomorphism
- Group isomorphism's
- Cayley's Theorem
- Properties of isomorphism
- Automorphisms

Textbook:
1. Contemporary Abstract Algebra, Joseph Gallian. (Ch. 1 to 6 and Ch .9)
2. I. N. Herstein, Topics in Algebra, Wiley. (Normal subgroup chapter).

Reference Books:
1. P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, Basic abstract Algebra, Second Ed.
2. J. B. Fraleigh, A. First Course in Abstract Algebra, Third Edition, Narosa publication.
3. M. Artin, Algebra, Prentice Hall of India, New Delhi.

Mapping of Program Outcomes with Course Outcomes

Class: TYBSc (Sem V) **Subject:** Mathematics
Course: Group Theory **Course Code:** MAT 3503
Weightage: 1=weak or low relation, 2=moderate or partial relation, 3= strong or direct relation.

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	3				2			2
CO 2	3	3		2	3	2			2
CO 3	3	3				2			2
CO 4	3	3				2			2
CO 5	3	3		2	2	2			2
CO 6	3	3				2			2
CO 7	3	3		2	2	2			2

Justification for the mapping

PO 1: Disciplinary Knowledge:
All of these course outcomes (COs) contribute to the student's development of abstract reasoning skills by working with the abstract algebraic structures inherent in group theory. For example, CO1, CO2, CO3, CO5, CO6 requires student to develop deep learning of groups, symmetry, subgroups, factor group, isomorphism of groups.CO4 and CO7 requires students to apply the concepts of Group Theory in many fields like engineering, chemistry and computer science.
PO2: Critical Thinking and Problem Solving:
All of these course outcomes (COs) contribute to the development of students critical thinking and problem solving. For example, CO1, CO2 CO3, CO5 requires students to think critically and apply these to solve complex problems in various filed like engineering and physics. CO4, CO6 and CO7 requires to apply and construct logical proofs to solve real world problems.
PO4: Research-related skills and Scientific temper:
CO2, CO5, CO7 contribute to the development of student's research related skills and scientific temper. For example, CO2 and CO7 requires students to develop their ability to think critically and apply knowledge to various field. CO5 requires students to apply knowledge of homomorphism to solve real life problems
PO5: Trans-disciplinary Knowledge:
CO2, CO5, CO7 requires students to apply group theory concepts in various fields like Chemistry, Engineering and Computer science.
PO6: Personal and professional competence:
All COs contribute to development of personal and professional competences. For example, all COs requires students to approach and solve complex problem systematically.
PO9: Self-directed and Life-long learning:
All these course outcomes contribute to development of student's ability to engage in self-directed and life-long learning. For example, all COs requires students to develop their ability to learn new concepts, form a simple proof and apply them to new problem.

Choice Based Credit System Syllabus (2019 Pattern)

Class: T.Y.B.Sc. (Semester – V)
Course Code: MAT 3504
Course: 4 **Title of the Course:** Ordinary Differential Equations
Credit: 3 **No. of Lectures:** 48

A) Course Objectives:

1. To understand basic concept of differential equations.
2. To solve first order differential equations.
3. To grasp the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations.
4. To solve differential equations using variation of parameter method, undetermined coefficient and by numerical methods.
5. To solve constant-coefficient linear second-order differential equations.
6. To demonstrate ability to think critically by determining and using appropriate techniques for solving a variety of differential equations.
7. To demonstrate the ability to integrate knowledge and ideas of differential equations in a coherent and meaningful manner for solving real world problems.

B) Course Outcomes:

1. Students will able to understand basic concept of differential equations.
2. Students will able to solve first order differential equations.
3. Student will able to grasp the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations.
4. Students will able to solve differential equations using variation of parameter method, undetermined coefficient and by numerical methods.
5. Student will able to solve constant-coefficient linear second-order differential equations.
6. Students will able to demonstrate ability to think critically by determining and using appropriate techniques for solving a variety of differential equations.
7. Students will able to demonstrate the ability to integrate knowledge and ideas of differential equations in a coherent and meaningful manner for solving real world problems.

TOPICS/CONTENTS:

Unit 01: Linear Differential Equations with constant coefficients[*12Lectures*]

- The auxiliary equations.
- Distinct roots, repeated roots, Complex roots.
- Particular solution.
- The operator $1/f\ (D)$ and its evaluation for the functions $x^m, e^{mx}, e^{axv}v$.
- The operator $1/(D^2 + a^2)$ acting on $sinax$ and $cosax$ with proofs.

Unit 02: Non-Homogeneous Differential Equations [*14Lectures*]

- Method of undetermined coefficients.
- Method of variation of parameters.
- Method of reduction of order.
- The use of a known solution to find another.

Unit 03: Power series solutions [*12Lectures*]

- Introduction and review of power series.
- Linear equations and power series.
- Convergence of power series.
- Ordinary points and regular singular points.

Unit 04: **System of First-Order Equations** [*10Lectures*]

- Introductory remarks
- Linear systems
- Homogeneous linear systems with constant Coefficients
- Distinct roots, repeated roots, Complex roots

Textbook:

Elementary Differential Equations, Rainville and Bedient, Macmillan Publication.

Reference Books:

- Differential Equations by George F. Simmons, Steven G. Krantz, Tata McGraw Hill.
- Ordinary and Partial Differential Equation, by M.D. Raisinghania, S. Chand and Company LTD, 2009.
- Daniel Murray, Introductory Course in Differential Equations, Orient Longman.

Mapping of Program Outcomes with Course Outcomes

Class: TYBSc (Sem V) **Subject:** Mathematics

Course: Ordinary Differential Equations **Course Code:** MAT 3504

Weightage: 1=weak or low relation, 2=moderate or partial relation, 3= strong or direct relation.

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	3							
CO 2	3	3		2	3				
CO 3	3	3							
CO 4	3	3							
CO 5	3	3		2	2				
CO 6	3	3							
CO 7	3	3		2	2				

Justification for the mapping

PO 1: Disciplinary Knowledge:

All of these course outcomes (COs) contribute to the development of student's ability to formation of solution of differential equations. For example, CO1, CO2, CO3, CO5 requires student to develop deep learning of solution of homogeneous and non-homogeneous ordinary differential equation. CO4, CO6 and CO7 requires students to apply the concepts of ordinary differential equations in many fields like engineering, chemistry and Biology.

PO2: Critical Thinking and Problem Solving:

All of these course outcomes (COs) contribute to the development of students critical thinking and problem solving. For example, CO1, CO2 CO3, CO5 requires students to think critically and apply these to solve complex problems in various filed like engineering and physics. CO4, CO6 and CO7 requires to solve real world problems.

PO4: Research-related skills and Scientific temper:

CO2, CO5, CO7 contribute to the development of student's research related skills and scientific temper. For example, CO2 and CO7 requires students to develop their ability to think critically and apply knowledge to various field. CO5 requires students to apply knowledge of homomorphism to solve real life problems

PO5: Trans-disciplinary Knowledge:

CO2, CO5, CO7 requires students to apply differential equations concepts in various fields like Chemistry, Engineering and Physics.

Choice Based Credit System Syllabus (2019 Pattern)

Class: T.Y.B.Sc. (Semester – V)
Course Code: MAT 3505
Course: 5 **Title of the Course:** Operations Research
Credit: 2 **No. of Lectures:** 48

A) Course Objectives:

1. To familiarize students with the basic concepts, terminologies, and constraints involved in linear programming problems, enabling them to articulate problem formulations effectively.
2. Develop students' proficiency in graphically representing and solving linear programming problems using the graphical method, including identifying feasible regions, optimal solutions, and sensitivity analysis.
3. Enable students to apply the simplex method algorithmically to solve complex linear programming problems, emphasizing the understanding of pivot operations and iterations.
4. Equip students with the skills to handle linear programming problems with constraints that require artificial variables using the Big-M method, focusing on conversion and manipulation techniques.
5. Introduce students to graphical sensitivity analysis methods to assess the impact of changes in objective function coefficients, resource availability, and constraint boundaries on optimal solutions.
6. To enable students to understand and apply the concept of duality in Linear Programming (LP) problems, exploring its significance, properties, and practical implications.
7. To familiarize students with the core concepts, algorithms, and mathematical techniques used in transportation modeling, enabling them to comprehend the underlying principles of optimization in transportation systems.
8. To equip students with the ability to identify, formulate, and solve transportation problems using appropriate mathematical models and optimization techniques. This includes practical applications in logistics, supply chain management, and urban transportation planning.
9. To familiarize students with the fundamental principles and concepts underlying assignment models in Operations Research, including the Hungarian method, transportation problems, and linear programming techniques used in solving assignment problems.

B) Course Outcomes:

1. Students will demonstrate the ability to formulate real-world problems into mathematical linear programming models, identifying decision variables, constraints, and the objective function accurately.
2. Students will be able to graphically solve and interpret linear programming problems, accurately identifying feasible regions, optimal solutions, and performing sensitivity analysis on graphical representations.
3. Students will apply the simplex method proficiently to solve multi-variable linear programming problems, showcasing competence in formulating initial tables, conducting iterations, and identifying optimal solutions.

4. Students will exhibit proficiency in applying the Big-M method to solve problems with artificial variables, manipulating constraints effectively, and transitioning between phases while solving LP problems.
5. Students will be able to explain the concept of duality in Linear Programming, outlining its mathematical basis and relevance in optimization problems.
6. Students will be able to develop and implement transportation models to optimize logistical operations, effectively analyze transportation networks, and propose strategic solutions for minimizing transportation costs, maximizing efficiency, and addressing complex real-world transportation challenges.
7. Students will be proficient in formulating assignment problems in different contexts (such as workforce allocation, resource assignment, task optimization) as mathematical models. They will demonstrate the capability to apply appropriate algorithms and techniques, like the Hungarian algorithm or linear programming, to solve these assignment problems efficiently and effectively.

TOPICS/CONTENTS:

Unit 01: Modeling with Linear Programming [*08 Lectures*]

- Two variable LP Model
- Graphical LP solution
- Selected LP Applications
- Graphical Sensitivity analysis

Unit 02: The Simplex Method [*16 Lectures*]

- LP Model in equation form
- Transition from graphical to algebraic solutions
- The simplex method
- Artificial starting solutions.

Unit 03: Duality [*06 Lectures*]

- Definition of the dual problem
- Primal dual relationship

Unit 04: Transportation Model [*12 Lectures*]

- Definition of the Transportation model
- The Transportation algorithm

Unit 05: Assignment Model [*06 Lectures*]

- The Hungarian method
- Simplex explanation of the Hungarian method.

Text Book:

Hamdy A. Taha, *Operation Research* (8^{th}Edition, 2009), Prentice Hall of India Pvt. Ltd, New Delhi.

Ch.2: 2.1,2.2,2.3(2.3.4, 2.3.5, 2.3.6). Ch.3: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6 (3.6.1).

Ch.4: 4.1, 4.2. Ch.5: 5.1,5.3 (5.3.1, 5.3.2, 5.3.3), 5.4(5.4.1, 5.4.2).

Reference Books:

1. Frederick S. Hillier, Gerald J. Lieberman, *Introduction to Operation Research* (8^{th} Edition) Tata McGraw Hill.
2. J. K. Sharma, *Operations Research: Theory and Applications*, (2^{nd} Edition, 2006), Macmilan India Ltd.
3. Hira and Gupta, *Operation Research*.

Mapping of Program Outcomes with Course Outcomes

Class: TYBSc (Sem V) **Subject:** Mathematics
Course: Operations Research **Course Code:** MAT 3505
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	2	2				1			
CO 2	3	2			1				
CO 3	2	2							
CO 4	3	3		1	1			1	1
CO 5	2	1							
CO 6	3	2		1	1	1		1	1
CO 7	2	2			1				1

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Students will apply linear programming to convert real-world problems into mathematical models, showcasing adeptness in defining decision variables, constraints, and objective functions, vital in problem-solving within the discipline.

CO2: Students will acquire vital analytical skills by graphically solving linear programming problems, enabling them to identify feasible regions, optimal solutions, and conduct sensitivity analysis, fostering a deeper understanding of quantitative decision-making.

CO3: Students will master the simplex method to efficiently tackle multi-variable linear programming problems, demonstrating expertise in constructing tables, performing iterations, and recognizing optimal solutions within Disciplinary Knowledge.

CO4: Students demonstrate mastery in utilizing the Big-M method by efficiently employing artificial variables, effectively manipulating constraints, and smoothly transitioning between phases when solving Linear Programming (LP) problems.

CO5: Duality in Linear Programming provides a complementary perspective by establishing relationships between primal and dual problems, enabling students to comprehend optimization trade-offs and derive optimal solutions efficiently in various disciplinary applications.
CO6: Students will gain expertise in transportation modeling to optimize logistics, analyze networks, and propose cost-effective strategic solutions, addressing real-world transportation challenges comprehensively.
CO7: Equips students with the expertise to translate real-world scenarios into mathematical models and adeptly utilize algorithms such as the Hungarian algorithm or linear programming for optimal problem-solving in diverse contexts.

PO2: Critical Thinking and Problem Solving
CO1: Developing linear programming models sharpens analytical skills by translating real-world problems into mathematical formulations, clarifying decision variables, constraints, and the objective function with precision.
CO2: Graphical linear programming enables students to visually analyze constraints, pinpoint feasible regions, optimize solutions, and conduct sensitivity analysis, fostering critical thinking in problem-solving.
CO3: Students will demonstrate critical thinking and problem-solving skills by efficiently utilizing the simplex method to navigate complex multi-variable linear programming problems, displaying adeptness in constructing initial tables, performing iterative calculations, and discerning optimal solutions.
CO4: Students will develop problem-solving skills by mastering the Big-M method, efficiently handling artificial variables, constraints, and seamlessly transitioning between phases in Linear Programming problem-solving.
CO5: Understanding duality in Linear Programming offers a dual perspective to optimization, presenting a mathematical basis for exploring alternative solutions and providing valuable insights into the primal problem, fostering critical thinking and problem-solving skills in tackling complex optimization challenges.
CO6: Empowering students with transportation modeling skills fosters the ability to strategically tackle real-world logistical challenges by optimizing networks, minimizing costs, and maximizing operational efficiency.
CO7: Students will enhance critical thinking by mastering diverse mathematical modeling techniques, like the Hungarian algorithm or linear programming, to proficiently solve assignment problems across various real-world scenarios, fostering effective problem-solving skills.

PO4: Research-related skills and Scientific temper
CO4: Mastering the Big-M method fosters adeptness in handling artificial variables, efficiently manipulating constraints, and seamlessly transitioning between phases, essential for resolving LP problems in research settings.
CO6: Students will acquire the expertise to devise and apply transportation models, enabling them to optimize logistics, analyze networks effectively, and propose strategic solutions, fostering a robust approach towards minimizing costs, maximizing efficiency, and addressing multifaceted real-world transportation challenges.

PO5: Trans-disciplinary Knowledge
CO2: Graphical solutions in linear programming facilitate comprehension of feasible regions, optimal solutions, and sensitivity analysis, aiding students' trans-disciplinary understanding of complex problem-solving and decision-making processes.
CO4: Mastering the Big-M method allows students to adeptly navigate artificial variables, manipulate constraints, and seamlessly transition phases, enabling effective problem-solving in Trans-disciplinary Knowledge.

CO6: Students will acquire essential skills to enhance logistical efficiency and tackle real-world transportation complexities by mastering transportation modeling and strategic optimization techniques within a trans-disciplinary framework.
CO7: Equipping students with diverse mathematical modeling skills and algorithmic techniques ensures adeptness in solving assignment problems across varied contexts, fostering trans-disciplinary problem-solving expertise.

PO6: Personal and Professional Competence
CO1: Enables strategic problem-solving by converting real-world scenarios into precise mathematical representations, optimizing decision-making through linear programming techniques.
CO6: Enables students to apply transportation models for cost-effective logistics, network analysis, and strategic problem-solving in real-world transportation scenarios, enhancing their personal and professional competence.

PO8: Environment and Sustainability
CO4: Mastering the Big-M method empowers students to navigate and solve complex environmental and sustainability problems by adeptly manipulating constraints and seamlessly transitioning between phases in linear programming.
CO6: Students will acquire expertise in transportation modeling to optimize logistics, analyze networks, and propose cost-effective, efficient solutions for real-world sustainability challenges in transportation.

PO9: Self-directed and Life-long Learning
CO4: Mastering the Big-M method enables seamless problem-solving by adeptly handling artificial variables, constraints manipulation, and phase transitions in Linear Programming, fostering self-directed and lifelong learning.
CO6: Empowering students with transportation modeling skills fosters lifelong learning by enabling them to strategically optimize logistics, analyze networks, and innovate solutions for cost reduction and efficiency enhancement in real-world transportation complexities.
CO7: Equipping students to translate real-world scenarios into mathematical models and apply relevant algorithms fosters adaptable problem-solving skills crucial for continual learning and self-directed problem resolution.

Choice Based Credit System Syllabus (2019 Pattern)

Class: T.Y.B.Sc. (Semester – V)
Course Code: MAT 3506
Course: 6 **Title of the Course:** Number Theory
Credit: 3 **No. of Lectures:** 48

A) Course Objectives:

1. Develop a solid understanding of divisibility properties of integers, including the Division Algorithm and the Fundamental Theorem of Arithmetic.
2. Introduce the concept of congruences and explore their properties, including residue classes and theorems like Fermat's, Euler's, and Wilson's.
3. Investigate the greatest integer function and related arithmetic functions like Euler's function, divisor function, sum of divisors function, and number of prime divisors function.
4. Introduce the concept of multiplicative functions and explore the Mobius function and its inversion formula.
5. Develop an understanding of quadratic residues, Legendre's symbol, and the Law of Quadratic Reciprocity.
6. Introduce Jacobi symbol as an extension of Legendre's symbol.
7. Expose students to Diophantine equations, focusing on linear equations (ax + by = c) and explore Pythagorean triplets as an example.

B) Course Outcomes:

1. Students will be able to apply divisibility properties and the Division Algorithm to solve problems involving integers.
2. Students will be able to perform operations on congruence classes and utilize theorems like Fermat's, Euler's, and Wilson's to solve problems.
3. Students will be able to calculate the greatest integer function and related arithmetic functions for various integers.
4. Students will be able to identify and utilize multiplicative functions, particularly the Mobius function and its inversion formula.
5. Students will be able to determine quadratic residues and apply Legendre's symbol to solve problems related to quadratic reciprocity.
6. Students will be able to understand the concept of Jacobi symbol and its connection to Legendre's symbol.
7. Students will be able to solve linear Diophantine equations and identify Pythagorean triplets using number theory concepts.

TOPICS/CONTENTS:

Unit 01: Divisibility [*8 Lectures*]

- Divisibility in integers, Division Algorithm
- GCD, LCM,
- Fundamental theorem of Arithmetic
- Infinitude of primes

Unit 02: Congruences [*12 Lectures*]

- Properties of Congruences
- Residue classes, complete and reduced residue system, their properties
- Fermat's theorem. Euler's theorem, Wilson's theorem
- Linear Congruences of degree 1
- Chinese remainder theorem

Unit 03: Greatest integer function [*10 Lectures*]

- Arithmetic functions Euler's function
- the number of divisors d(n)
- $\sigma\ (n)$, $\omega(n)\ and\ \Omega(n)$
- Multiplicative functions, Mobius function, Mobius inversion formula.

Unit 04: Quadratic Reciprocity [*10 Lectures*]

- Quadratic residues
- Legendre's symbol and its properties
- Law of quadratic reciprocity
- Jacobi symbol

Unit 05: Diophantine Equations [*8 Lectures*]

- Diophantine Equations ax + by = c
- Pythagorean triplets

Text Book:

I. Niven, H. Zuckerman and H.L. Montgomery, An Introduction to Theory of Numbers, 5th Edition, John Wiley and Sons.
(§1.1- §1.3, §2.1- §2.3, §3.1- §3.3, §4.1 -§4.3, §5.1 and §5.3.)

Reference Book:

David M. Burton, Elementary Number Theory (Second Ed.), Universal Book Stall, New Delhi, 1991.

Mapping of Program Outcomes with Course Outcomes

Class: TYBSc (Sem V) **Subject:** Mathematics
Course: Number Theory **Course Code:** MAT 3506
Weightage: 1=weak or low relation, 2=moderate or partial relation, 3= strong or direct relation.

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	3		2	2	2			2
CO 2	3	3		2	2	2			2
CO 3	2	2		2	1	2			2
CO 4	2	3		2	1	2			2
CO 5	2	3		2	1	2			2
CO 6	2	2		2	1	2			2
CO 7	3	3		3	2	3			3

Justification for the mapping

PO 1: Disciplinary Knowledge:
Mastery of divisibility and congruence is essential for understanding number theory concepts.
PO2: Critical Thinking and Problem Solving:
All COs require analytical skills to apply theorems and solve complex problems.
PO4: Research-related skills and Scientific temper:
The concepts explored can form the basis for research in number theory and its applications.
PO5: Trans-disciplinary Knowledge:
Understanding number theory is relevant in various fields, such as cryptography and computer science.
PO6: Personal and professional competence:
Mastering these concepts aids in professional applications and enhances personal competency in mathematics.
PO9: Self-directed and Life-long learning:
Engaging with number theory fosters independent study habits and lifelong learning in mathematics.

Choice Based Credit System Syllabus (2019 Pattern)

Class: T.Y.B.Sc. (Semester – V)
Course Code: MAT 3507
Course: 7 **Title of the Course:** Practical based on MAT 3501 and MAT 3502
Credit: 2 **No. of Lectures:** 48

A) Course Objectives:

1. Apply the principles of metric space topology to model and resolve practical problems in various fields such as computer science, engineering, physics, and data analysis.
2. Understand the concept of continuity in metric spaces, exploring its theoretical underpinnings and its practical applications.
3. Develop proficiency in applying the principles of continuity within metric spaces to solve real-world problems in various mathematical contexts.
4. Analyze and demonstrate an understanding of connectedness, compactness, and completeness in metric spaces through theoretical study and practical applications.
5. Apply the concepts of connectedness, compactness, and completeness in metric spaces to solve real-world mathematical problems in diverse fields, emphasizing practical relevance.
6. Analyze and manipulate functions, including composition, inverses, domains, ranges, and graphing techniques for real-valued functions.
7. Investigate advanced concepts like equivalence relations, countability, and the Cantor set.
8. Analyze and differentiate between convergent and divergent sequences, employing various convergence tests and techniques such as limit definitions, Cauchy sequences, and the comparison test.
9. To enable students to comprehend the concepts of convergence and divergence in series of real numbers.
10. To familiarize students with fundamental convergence tests such as the Comparison Test, Ratio Test, and Root Test.

B) Course Outcomes:

1. Students will be proficient in utilizing the topology of metric spaces to formulate and address real-life problems, demonstrating the practical applicability of mathematical concepts in diverse practical contexts.
2. Students will be capable of analyzing and solving practical problems involving continuity within metric spaces, demonstrating a clear understanding of its relevance and applications in diverse mathematical scenarios.
3. Students will proficiently utilize the principles of connectedness, compactness, and completeness in metric spaces to address practical mathematical challenges in various applied domains, showcasing the practical applicability of these concepts in problem-solving.
4. Students will be able to apply the concepts of equivalence relations, countability, and the Cantor set to solve complex problems in diverse areas, showcasing an understanding of their practical applications.
5. Students will be able to identify convergence or divergence in a given sequence of real numbers, analyze the behavior of sequences toward specific limits or infinity, and apply relevant tests to determine convergence or divergence.

6. Students will be able to apply their knowledge of convergence, divergence, and Cauchy sequences to model and analyze real-world scenarios, interpret their mathematical significance, and communicate findings effectively using mathematical reasoning.
7. Students will apply convergence tests rigorously to ascertain convergence or divergence of different series encountered in real-world applications.

Title of experiments:
Metric Spaces:
- Metric Spaces
- Sequences in Metric Spaces
- Cauchy Sequences
- Completion of a Metric Space
- Open and Closed Sets
- Relativisation and Subspaces
- Countability Axioms and Separability
- Baire's Category Theorem

Real Analysis 1:
- Sets and functions
- Equivalence and countability
- Sequence of real numbers
- Limit superior, limit inferior and Cauchy sequence
- Series of real numbers
- Conditional and absolute convergence of series

Mapping of Program Outcomes with Course Outcomes

Class: TYBSc (Sem V) **Subject:** Mathematics
Course: Practical based on MAT 3501 and MAT 3502 **Course Code:** MAT 3507
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	2	2							
CO 2	3	2							
CO 3	3	3			1				
CO 4	3	2			1				1
CO 5	3	3			1				
CO 6	2	2							
CO 7	3	3						1	1

Justification for the mapping

PO1: Disciplinary Knowledge
CO1: Students proficient in metric space topology can apply abstract mathematical concepts to solve real-world problems across various disciplines, showcasing the practical relevance of mathematics in diverse contexts.

CO2: Students will develop problem-solving skills in metric spaces, crucial for diverse mathematical applications requiring continuity comprehension.
CO3: Students proficient in connectedness, compactness, and completeness in metric spaces navigate real-world problem-solving across disciplines by employing fundamental mathematical principles.
CO4: Understanding equivalence relations, countability, and the Cantor set enables students to discern patterns, classify diverse data, and model complex systems across disciplines, fostering problem-solving prowess through practical application.
CO5: Understanding convergence and divergence in sequences of real numbers is foundational in various disciplines, enabling precise analysis of limits and applications of convergence tests for robust mathematical problem-solving.
CO6: Understanding convergence, divergence, and Cauchy sequences equips students with the tools to mathematically model real-world phenomena, interpret their implications, and communicate findings coherently, enhancing their disciplinary knowledge and analytical abilities.
CO7: Students rigorously apply convergence tests to ensure accuracy when determining the convergence or divergence of series in real-world applications within Disciplinary Knowledge.

PO2: Critical Thinking and Problem Solving
CO1: Students proficient in metric space topology can apply abstract mathematical concepts to solve real-world problems, showcasing critical thinking across various practical scenarios.
CO2: Students will develop critical thinking skills by mastering the analysis and resolution of real-world problems using continuity in metric spaces, showcasing its broad relevance across various mathematical contexts.
CO3: Students proficient in metric space principles enhance critical thinking by leveraging connectedness, compactness, and completeness to solve real-world problems across diverse applied fields, showcasing practicality in problem-solving.
CO4: Understanding equivalence relations, countability, and the Cantor set cultivates analytical skills essential for tackling multifaceted problems across disciplines, demonstrating the practicality of abstract mathematical concepts in fostering critical thinking and problem-solving prowess.
CO5: Understanding convergence or divergence in sequences of real numbers enhances critical thinking by sharpening analytical skills and applying test strategies to ascertain the behavior of sequences towards specific limits or infinity.
CO6: Understanding convergence, divergence, and Cauchy sequences equips students with the essential tools to analyze real-world scenarios through mathematical models, fostering effective communication and interpretation of findings to solve complex problems.
CO7: Applying convergence tests rigorously ensures accurate determination of convergence or divergence, crucial for real-world applications' validity and reliability in Critical Thinking and Problem Solving.

PO4: Research-related skills and Scientific temper
CO5: Mastering Cauchy criteria empowers students to rigorously assess convergence, analyze sequence properties, and apply theorems effectively, fostering essential research skills and a scientific mindset for problem-solving in real sequences.

PO5: Trans-disciplinary Knowledge
CO3: Utilizing connectedness, compactness, and completeness in metric spaces enhances problem-solving across diverse fields by enabling rigorous analysis and solution development in trans-disciplinary contexts.

CO4: Understanding equivalence relations, countability, and the Cantor set enables students to unravel intricate problems across disciplines, fostering a versatile problem-solving approach essential in trans-disciplinary fields.
CO5: Understanding convergence and divergence in sequences of real numbers is essential across various disciplines as it facilitates analysis of patterns, predictions of outcomes, and modeling behaviors in diverse systems.

PO8: Environment and Sustainability
CO7: Applying convergence tests rigorously ensures accurate determination of series convergence or divergence, critical in modeling and analyzing real-world environmental and sustainability phenomena.

PO9: Self-directed and Life-long Learning
CO4: Understanding equivalence relations, countability, and the Cantor set fosters problem-solving skills across diverse fields, facilitating self-directed learning by applying these concepts practically, thereby nurturing life-long learning capabilities.
CO7: Rigorous application of convergence tests ensures accurate determination of convergence or divergence in series, vital for real-world applications, fostering self-directed and lifelong learning in mathematical analysis.

Choice Based Credit System Syllabus (2019 Pattern)

Class: T.Y.B.Sc. (Semester – V)
Course Code: MAT 3508
Course: 8 **Title of the Course:** Practical based on MAT 3503 and MAT 3504
Credit: 2 **No. of Lectures:** 48

A) Course Objectives:

1. To demonstrate when a binary algebraic structure is a group.
2. To determine possible subgroup of a group.
3. To understand the isomorphism between two groups.
4. To understand the symmetry of regular n-gon.
5. To understand the genesis of ordinary differential equations.
6. To learn various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order.
7. To understand the formation of modelling problems in ordinary differential equations and apply some standard methods to obtain its solutions.

B) Course Outcomes:

1. Students will able to demonstrate when a binary algebraic structure is a group.
2. Students will able to determine possible subgroup of a group.
3. Students will understand the isomorphism between two groups.
4. Students will able to understand the symmetry of regular n-gon.
5. Student will able to understand the genesis of ordinary differential equations.
6. Student will able to learn various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order.
7. Students will able to understand the formation of modelling problems in ordinary differential equations and apply some standard methods to obtain its solutions.

Title of experiments:
Group Theory:

- Elementary properties of groups
- Finite Groups and Subgroups
- Cyclic Groups
- Permutation Groups
- Normal Subgroup
- Homomorphism and Isomorphism's

Ordinary Differential Equations:

- Linear Differential Equations with constant coefficients
- Non-Homogeneous Differential Equations
- Power series solutions
- System of First-Order Equations

Mapping of Program Outcomes with Course Outcomes

Class: TYBSc (Sem V) **Subject:** Mathematics
Course: Practical based on MAT 3503 and MAT 3504 **Course Code:** MAT 3508
Weightage: 1=weak or low relation, 2=moderate or partial relation, 3= strong or direct relation.

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	3							
CO 2	3	3							
CO 3	3	3		3	2				
CO 4	3	2							
CO 5	3	2							
CO 6	3	2		2	2				
CO 7	3	2		2	2				

Justification for the mapping

PO 1: Disciplinary Knowledge:

All of these course outcomes (COs) contribute to the development of student's develop abstract reasoning skills by working with the abstract algebraic structures inherent in group theory and solution of ordinary differential equations. For example, CO1, CO2, CO3 requires student to develop deep learning of solution of homogeneous and non-homogeneous ordinary differential equation. CO4, CO5, CO6 and CO7 requires students to apply the concepts of ordinary differential equations in many fields like engineering, chemistry and Biology.

PO2: Critical Thinking and Problem Solving:

All of these course outcomes (COs) contribute to the development of students critical thinking and problem solving. For example, CO1, CO2 CO3 requires students to think critically and apply these to solve complex problems in various filed like engineering and physics. CO4, CO5, CO6 and CO7 requires to solve real world problems.

PO4: Research-related skills and Scientific temper:

CO3, CO6, CO7 contribute to the development of student's research related skills and scientific temper. For example, CO3 requires students to develop their ability to think critically and apply knowledge to various field. CO6 and CO7 requires students to apply knowledge of homomorphism to solve real life problems

PO5: Trans-disciplinary Knowledge:

CO3, CO6, CO7 requires students to apply isomorphism and differential equations concepts in various fields like Chemistry, Engineering and Physics.

Choice Based Credit System Syllabus (2019 Pattern)

Class: T.Y.B.Sc. (Semester – V)
Course Code: MAT 3509
Course: 9 **Title of the Course:** Practical based on MAT 3505 and MAT 3506
Credit: 2 **No. of Lectures:** 48

A) Course Objectives:

1. To familiarize students with the basic concepts, terminologies, and constraints involved in linear programming problems, enabling them to articulate problem formulations effectively.
2. Equip students with the skills to handle linear programming problems with constraints that require artificial variables using the Big-M method, focusing on conversion and manipulation techniques.
3. To familiarize students with the core concepts, algorithms, and mathematical techniques used in transportation modeling, enabling them to comprehend the underlying principles of optimization in transportation systems.
4. To equip students with the ability to identify, formulate, and solve transportation problems using appropriate mathematical models and optimization techniques. This includes practical applications in logistics, supply chain management, and urban transportation planning.
5. To familiarize students with the fundamental principles and concepts underlying assignment models in Operations Research, including the Hungarian method, transportation problems, and linear programming techniques used in solving assignment problems.
6. To enable students to apply congruence concepts practically in cryptography, coding theory, and other real-world applications.
7. To enable undergraduate students to comprehend and apply the greatest integer function in various real-world scenarios, such as modeling discrete quantities and analyzing step functions in practical contexts.
8. To equip students with a deep understanding of quadratic reciprocity and its practical applications in cryptography, number theory, and other fields.

B) Course Outcomes:

1. Students will demonstrate the ability to formulate real-world problems into mathematical linear programming models, identifying decision variables, constraints, and the objective function accurately.
2. Students will apply the simplex method proficiently to solve multi-variable linear programming problems, showcasing competence in formulating initial tables, conducting iterations, and identifying optimal solutions.
3. Students will be able to develop and implement transportation models to optimize logistical operations, effectively analyze transportation networks, and propose strategic solutions for minimizing transportation costs, maximizing efficiency, and addressing complex real-world transportation challenges.
4. Students will be proficient in formulating assignment problems in different contexts (such as workforce allocation, resource assignment, task optimization) as mathematical models. They will demonstrate the capability to apply appropriate algorithms and techniques, like

the Hungarian algorithm or linear programming, to solve these assignment problems efficiently and effectively.

5. Students will be able to analyze and implement congruence-based algorithms in practical scenarios, such as encryption techniques or error-detection mechanisms in digital communication systems.
6. Students will proficiently utilize the greatest integer function to model and solve practical problems encountered in fields like computer science, economics, and engineering, demonstrating its applicability in discrete data representation and algorithmic design.
7. Students will proficiently apply the principles of quadratic reciprocity to solve complex mathematical problems in cryptography, number theory, and related practical domains, demonstrating their ability to employ this concept in real-world applications.

Title of experiments:
Operations Research:

- Formulation of LPP
- Graphical solution to LPP
- Simplex method
- Big-M method
- Duality in LPP
- Graphical sensitivity in LPP
- Transportation problems
- Assignment Problems

Number Theory:

- Divisibility
- Congruences
- Greatest integer function
- Quadratic Reciprocity
- Diophantine Equations

Mapping of Program Outcomes with Course Outcomes

Class: TYBSc (Sem V) **Subject:** Mathematics
Course: Practical based on MAT 3505 and MAT 3506 **Course Code:** MAT 3509
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	2	2				1			
CO 2	2	2		1	1			1	1
CO 3	3	2		1	1	1		1	1
CO 4	2	2			1				1
CO 5	3	2							
CO 6	2	2							
CO 7	2	2							

Justification for the mapping

PO1: Disciplinary Knowledge
CO1: Students will apply linear programming to convert real-world problems into mathematical models, showcasing adeptness in defining decision variables, constraints, and objective functions, vital in problem-solving within the discipline.
CO2: Students will master the simplex method to efficiently tackle multi-variable linear programming problems, demonstrating expertise in constructing tables, performing iterations, and recognizing optimal solutions within Disciplinary Knowledge.
CO3: Students will gain expertise in transportation modeling to optimize logistics, analyze networks, and propose cost-effective strategic solutions, addressing real-world transportation challenges comprehensively.
CO4: Equips students with the expertise to translate real-world scenarios into mathematical models and adeptly utilize algorithms such as the Hungarian algorithm or linear programming for optimal problem-solving in diverse contexts.
CO5: Students will gain proficiency in applying congruence-based algorithms for encryption and error detection in digital communication systems, enhancing their disciplinary knowledge.
CO6: Utilizing the greatest integer function facilitates precise discrete data representation and algorithmic design, crucial across computer science, economics, and engineering for solving practical problems effectively.
CO7: Application of quadratic reciprocity enables students to solve intricate cryptographic and number theory problems, fostering their adeptness in real-world contexts and practical domains.

PO2: Critical Thinking and Problem Solving
CO1: Developing linear programming models sharpens analytical skills by translating real-world problems into mathematical formulations, clarifying decision variables, constraints, and the objective function with precision.
CO2: Students will demonstrate critical thinking and problem-solving skills by efficiently utilizing the simplex method to navigate complex multi-variable linear programming problems, displaying adeptness in constructing initial tables, performing iterative calculations, and discerning optimal solutions.
CO3: Empowering students with transportation modeling skills fosters the ability to strategically tackle real-world logistical challenges by optimizing networks, minimizing costs, and maximizing operational efficiency.
CO4: Students will enhance critical thinking by mastering diverse mathematical modeling techniques, like the Hungarian algorithm or linear programming, to proficiently solve assignment problems across various real-world scenarios, fostering effective problem-solving skills.
CO5: Students develop critical thinking by applying congruence-based algorithms to real-world scenarios like encryption or error-detection, fostering problem-solving skills in digital communication systems.
CO6: The greatest integer function serves as a fundamental tool for modeling real-world scenarios in discrete data analysis, algorithmic design, and problem-solving across computer science, economics, and engineering disciplines.
CO7: Mastering quadratic reciprocity fosters critical thinking and problem-solving skills vital for tackling intricate cryptographic challenges and practical applications in number theory.

PO4: Research-related skills and Scientific temper
CO2: Mastering the Big-M method fosters adeptness in handling artificial variables, efficiently manipulating constraints, and seamlessly transitioning between phases, essential for resolving LP problems in research settings.

CO3: Students will acquire the expertise to devise and apply transportation models, enabling them to optimize logistics, analyze networks effectively, and propose strategic solutions, fostering a robust approach towards minimizing costs, maximizing efficiency, and addressing multifaceted real-world transportation challenges.

PO5: Trans-disciplinary Knowledge

CO2: Mastering the Big-M method allows students to adeptly navigate artificial variables, manipulate constraints, and seamlessly transition phases, enabling effective problem-solving in Trans-disciplinary Knowledge.

CO3: Students will acquire essential skills to enhance logistical efficiency and tackle real-world transportation complexities by mastering transportation modeling and strategic optimization techniques within a trans-disciplinary framework.

CO4: Equipping students with diverse mathematical modeling skills and algorithmic techniques ensures adeptness in solving assignment problems across varied contexts, fostering trans-disciplinary problem-solving expertise.

PO6: Personal and Professional Competence

CO1: Enables strategic problem-solving by converting real-world scenarios into precise mathematical representations, optimizing decision-making through linear programming techniques.

CO3: Enables students to apply transportation models for cost-effective logistics, network analysis, and strategic problem-solving in real-world transportation scenarios, enhancing their personal and professional competence.

PO8: Environment and Sustainability

CO2: Mastering the Big-M method empowers students to navigate and solve complex environmental and sustainability problems by adeptly manipulating constraints and seamlessly transitioning between phases in linear programming.

CO3: Students will acquire expertise in transportation modeling to optimize logistics, analyze networks, and propose cost-effective, efficient solutions for real-world sustainability challenges in transportation.

PO9: Self-directed and Life-long Learning

CO2: Mastering the Big-M method enables seamless problem-solving by adeptly handling artificial variables, constraints manipulation, and phase transitions in Linear Programming, fostering self-directed and lifelong learning.

CO3: Empowering students with transportation modeling skills fosters lifelong learning by enabling them to strategically optimize logistics, analyze networks, and innovate solutions for cost reduction and efficiency enhancement in real-world transportation complexities.

CO4: Equipping students to translate real-world scenarios into mathematical models and apply relevant algorithms fosters adaptable problem-solving skills crucial for continual learning and self-directed problem resolution.